THE CARPAL TUNNEL SYNDROME

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The carpal tunnel is a channel with fibro-osseous walls leading from the deep flexor space of the forearm into the palm of the hand. Superficially it is bounded by the flexor retinaculum which stretches from the trapezium and scaphoid laterally to the pisiform and hamate medially. This tough sheet blends proximally with the deep fascia of the forearm and distally with the palmar aponeurosis. The floor and sloping sides of the tunnel consist of the capsules of the radio-carpal and inter-carpal joints and the periosteum of the carpus itself. The contents are the tendons of the fingers and thumb and the median nerve.

Motor and sensory changes in the hand have long been known to result from lesions of the median nerve at the wrist and at other sites. However, only in the last ten years has compression of the nerve in the carpal tunnel been recognized as responsible for the common syndrome of acroparaesthesiae (McArdle, 1949; Kremer *et al.*, 1953). This term was first used by Schultze (1893) to describe paroxysmal nocturnal tingling in the hands of middle-aged women. It used generally to be held that such symptoms were either vascular in origin or were caused by nerve compression at the root of the neck. Some authors, notably Walshe (1945, 1951, 1955), still hold this to be so, though the fact that the wrist is the site of trouble seems proven by tests of conduction time in the median nerve.

Symptoms and Signs

The condition is most commonly seen in women at or shortly after the menopause. It is also not uncommonly seen in pregnancy, coming on in the second trimester and usually, but not invariably, remitting spontaneously after delivery. Men are rarely affected with acroparaesthesiae.

The principal symptoms of the carpal tunnel syndrome are paroxysmal burning and tingling in the fingers and hand, characteristically sparing the fifth finger and being most troublesome in the second and third digits. These occur most frequently at night with consequent disturbance of sleep. Most patients will report that they have

attempted to relieve their discomfort by getting up and walking about or by hanging their hands out of bed. As the condition progresses, aching pain is experienced up the forearm as far as the elbow and even occasionally in the upper arm, and it is this yet unexplained radiation of pain that has hitherto focused interest upon the neck. Characteristically many patients will describe their hands as feeling swollen and clumsy in the morning—'like a string of sausages' is a frequent simile; but after a few minutes this passes off. With progression of the condition the tingling and pain occur by day, being exacerbated by use. Function is markedly disturbed, paraesthesiae and disordered sensation making sewing difficult while heavy work of the hands such as in wringing clothes will often produce a paroxysm. Clumsiness of both motor and sensory origin is noted. Increased breakage of crockery is sometimes a marked complaint. The syndrome is usually unilateral at its onset and is found first in the most used hand. The other one commonly seems to become involved to a greater or lesser extent when it is used more often to spare that first affected. Physical signs may or may not be present in this condition. There is often surprisingly little correlation between the severity of paraesthesiae and accompanying abnormality on investigation. Signs of hypoaesthesia and hypalgesia in median nerve territory may be found together with evidence of reduction in power and bulk of the thenar muscles. Here, the most important signs are reduction in power and range of abduction of the thumb. The function of abductor pollicis brevis should be tested by asking the patient with supine hand to point her thumb up toward the ceiling. The muscle bulk is assessed by ease of palpation of the first metacarpal shaft.

Aetiology

In the majority of patients, no clear aetiology is evident. There does not appear to be any intrinsic disorder of the nerve or retinaculum. Conduction tests, however, show clearly that the

FIG. 1.—A shows the distribution of the median nerve in the palm of the hand. The shaded area represents the site of sensory loss and paraesthesiae. B shows the dermatomes of the palm.

segment of the nerve affected is that which lies in the carpal tunnel. The assumption that disturbance of function in the nerve is due to compression must remain a *post hoc* argument based on the relief that follows decompression of the tunnel. The common occurrence of the condition at the menopause and in pregnancy suggests that endocrine factors may play an important part in its causation. It has been suggested that as a result of hormonal activity there is excessive retention of water. This leads to swelling of connective tissue or possibly micro-oedema of nerve or retinaculum. In this connection, two further facts are of interest and possible significance. Firstly, the comparable condition of meralgia paraesthetica also has an increased frequency in pregnancy and secondly, another condition due to disturbance of connective tissue, namely trigger finger, has an increased incidence in patients with the carpal tunnel syndrome.

There remains the smaller group with some definite compression of the nerve. The most important conditions in this group include injuries around the wrist, particularly old malunited Colles's and Smith's fractures, dislocation of the lunate and soft tissue lesions such as scarring following wounds in this region. Swellings of the

median nerve itself such as neurinoma and neurofibroma are also rare causes.

The remainder of the cases are associated with tendon or sheath swellings, ganglia, rheumatoid and osteo-arthritis of the wrist (Cyriax, 1954). Recently some cases associated with suppurative tenosynovitis were described which were relieved by drainage of pus.

Investigation and Differential Diagnosis

In the great majority of cases the patient's story is absolutely typical and the diagnosis can confidently be made on this alone.

Important differential diagnoses are from cervical rib and cervical spondylosis. Here, the recognition of symptoms and signs as being within median nerve territory rather than of root distribution is vital (see Fig. 1). Sometimes tennis elbow, tenosynovitis and vascular disorders such as Raynaud's phenomenon may also cause confusion, though their nature will always be evident from the history and examination.

More proximal lesions of the nerve should be excluded by assessing power and bulk of long finger and wrist flexors. The neck and axilla should be examined and carefully palpated to exclude glandular or other swellings.

Vascular anomalies in hand and arm are sought, as should be lesions of radial and ulnar nerves. When any doubt exists as to the presence of cervical ribs and other bony abnormalities, radiographs should be taken of neck and wrist.

The diagnosis may be confirmed by the tourniquet test (Gilliat and Wilson, 1953) where paraesthesiae and sensory loss may be induced by pneumatic tourniquet pressure. Paraesthesiae and pain identical with that occurring spontaneously comes on within one minute of inflating to 200 mm. of mercury pressure a sphygmomanometer cuff placed around the upper arm. After several minutes of ischaemia, sensory loss will develop and this often develops earlier in median than in ulnar distribution in patients with the carpal tunnel syndrome. Probably the most valuable confirmation is the demonstration of a prolonged median nerve conduction time. This, however, involves apparatus and experience not always available in many hospitals. Tapping over the nerve at the wrist occasionally produces tingling in the fingers but this is a rather variable phenomenon.

Treatment

When a definite compressing lesion is known appropriate surgery is indicated. In the majority of patients with no obvious case for the condition, treatment may be operative or conservative. The latter consists of rest in splints which may be made of plastic or plaster of Paris. These are worn either constantly or only at night and the wrist should be supported in a position of function with 10° of dorsiflexion. Trial of the splint may be continued for between two and three weeks in the first instance.

This form of management is indicated in two groups of people—those whose symptoms have appeared acutely and a second group in which a transient aetiological agent such as pregnancy can be recognized. It has little place in patients with prolonged symptoms and no place at all in those who have any established motor or sensory deficit. For these people the greatest chance of cure lies in surgery.

The principle of operative treatment is straightforward, as all that is required is division of the flexor retinaculum as predicted by McArdle (1949) and described fully by Kremer *et al.* (1953). This may be performed in one of two ways. In the first of these, the retinaculum is exposed and then divided—the 'open' operation. A very satisfactory alternative is the 'closed' operation when a blind division of the retinaculum is carried out. It is emphasized that neither of these procedures should be undertaken lightly. Whichever is used,

consistent technique, adequate anaesthesia and a bloodless field are essential.

The open operation may be performed either through an incision along the distal wrist crease, curving into the palm along the crease at the base of the thenar eminence, or through a straight longitudinal incision across the wrist into the proximal palm. Either incision will expose the retinaculum, palmaris longus tendon and the underlying deep fascia. This fascia is opened just proximal to its junction with the flexor retinaculum and a flat dissector is passed into the palm under the retinaculum which is then divided. The nerve will be seen lying embedded in connective tissue which need not be disturbed. After complete division is assured the skin wound is closed accurately by fine silk sutures. Dressings are applied, including a palmar pad of cotton wool. A crepe bandage is then put on firmly over this and the tourniquet is released. Alternatively the tourniquet may be released prior to skin suture and consequent bleeding controlled. It is the surgeon's responsibility to keep the patient under observation until he is quite certain of adequate circulatory return.

The closed operation has several variants and the one to be described has been used routinely and found valuable at the Middlesex Hospital for several years. After a tourniquet has been applied, a short transverse incision is made in the distal wrist crease and deepened to define the junction of the palmaris longus tendon and flexor retinaculum. A segment of the tendon is excised to prevent adherence of the tendon to the skin scar which often provides discomfort. The deep fascia is exposed, incised transversely and the median nerve identified. A Macdonald's dissector (Fig. 2) is passed proximally in the easily definable plane under the fascia, half an inch of which is divided longitudinally. The dissector is then passed distally and can be felt to glide under the corrugated deep surface of the retinaculum into the palm where the tip can be felt with ease. Once the tip can be felt it should not be passed further. This will avoid damage to the superficial palmar arch. A straight bistoury (Fig. 2) is introduced over the dissector with its guarded edge facing radially to avoid danger to the motor branch of the nerve. The blade of the bistoury is turned upwards and the retinaculum is divided with a sawing motion as the bistoury is withdrawn. The nerve is protected at this stage by the underlying dissector which is used after removal of the bistoury to assess completeness of decompression. Any residual strands of retinaculum left undivided should be exposed by a short extra palmar incision rather than 'fished for' blindly. The skin wound is then closed with silk sutures and a pressure

FIG. 2.—The key instruments in the closed operation. *Above*—A well sharpened bistoury. *Below*—A Macdonald's dissector.

bandage applied over cotton wool prior to release of the tourniquet.

The closed operation has been most satisfactory but should not be used when there is any deformity of the wrist following injuries such as Colles's fracture. Neither should it be used for any second operation upon the retinaculum or where nerve inspection or biopsy is required.

After-care is important though simple. When the patient is returned to the ward, the hand is kept suspended for 18 to 24 hours and is inspected frequently for any colour change. After 24 hours the pressure bandage is removed, a light dressing is applied and the patient is allowed home. She is advised to use the hand as little as possible for the next two weeks. The stitches are usually removed after eight days.

This condition is frequently bilateral and it is generally found most satisfactory to operate on only one wrist at a time. Bilateral operations do not make for post-operative comfort. It is much better in most cases to operate on the worst side first and then to wait for some weeks. Regression of symptoms in the other hand is common enough for a waiting policy to give good results in many cases.

Results

The results of treatment in those patients who complain only of paraesthesiae are excellent. Within days of operation, not only the par-

aesthesiae but also the commonly associated sensations of aching and swelling are lost. When established sensory loss was noted before operation, return of critical sensation is often slower and several weeks may elapse before improvement starts. Motor dysfunction with wasting is slower still to respond. Weakness may persist for several months and where muscle bulk is grossly reduced and fibrosis has occurred, complete recovery may never occur. Before any surgery is carried out, it is important to discuss the prognosis with patients in the light of their symptoms.

Acknowledgment

I am most grateful to Mr. L. P. Le Quesne for his advice and encouragement during the preparation of the article. I thank also Dr. J. Swithinbank for his help.

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